



REProMag

Resource Efficient Production of Magnets



Dear Reader,

Another seven months to go, but if looking backwards, the last two and a half years rushed by and there is no reason why these seven remaining will pass any slower. A lot of work has been done in REProMag and a very distinguished magnets expert recently said to us: “You have done a miracle. I never thought that such a dirty process as metal injection moulding would work with NdFeB.” With “dirty” he meant of course carbon and oxygen, likely to be picked up during the numerous processing steps. We have to admit there were times in the beginning, when we thought exactly the same...

Well, with the right feedstock and elaborated processing parameters, we did it – however, the devil sits in detail, and that’s where we do some daily exorcism right now when producing the demonstrator parts...

Extremely exciting are also our 3D-printing activities: we are able now to print 3D green parts with complex shapes in quite a range of materials, both by Fused Filament Fabrication (FFF) and by Lithography-based Ceramic Manufacturing (LCM). We are still working on NdFeB compositions though, as again the interaction between processing

and feedstock also here is a tricky one. But hey, that’s why we love research and development, isn’t it? Stefan Hampel of HAGE will tell us more about it in this 4th REProMag newsletter.

Again, we will provide interesting facts on the project’s research and development activities and presents information on relevant events within and outside of the project consortium on our road to waste-free production of NdFeB-type magnets.

Welcome to the exciting world of magnets. We hope you’ll enjoy reading our newsletter and look forward to your feedback!

Yours sincerely,

The REProMag consortium


Enjoy our project video:



REProMag ID

Content

Title:
Resource Efficient Production Route for Rare Earth Magnets



Programme:
H2020-FoF-2014

Duration:
01.01.2015 - 31.12.2017

Partner countries:
Austria, France, Germany, Slovenia, United Kingdom

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... and for more information on the project and the partners, please also have a look at our [website](#)

Showcasing: REProMag 3D printing solution

Whether in electrical motors of cars, sensors of elevators, actuators of medical equipment, grippers and fixations of machines, speakers of cell phones or hard drives of computers: rare-earth (RE) magnets are increasingly involved in our lives and a wide range of industries. They are simply the strongest type of magnets to date and as such, high in demand. Yet, rare earths are a group of chemically similar metallic elements occurring together in relatively scarce minerals: they are both difficult to find and to extract in large quantities, which drives their price high. Their mining is also associated with environmental damages.

Taking these problematics into account, what is to do with the **prototypes** any industry needs to develop and test before getting to a mature new device? Or with a **few amount of customised magnets** for special projects?

The conventional production routes for RE-magnets, such as press and sinter methods, tend not to be adapted to these situations: In the press and sinter route, a magnetic alloy is pulverized into fine powder, compacted and heated to cause densification via “liquid phase sintering”¹. The sintered magnets then need to be cut into the desired shape, which represents an inefficient material and unacceptable loss considering the expensive and scarce RE-materials.

Even Metal Injection Moulding (MIM), one method used by the REProMag team for its innovative production route Shaping, Debinding Sintering (SDS), is not the most suitable solution when it comes to prototypes or small scale production. The time, material and money

invested in the design and fabrication of the mould, into which heated magnetic material is forced, makes MIM a better method for large scale production of magnets with identical shape.

With these requirements in mind, the REProMag partners decided to also use Additive Manufacturing (AM) in the SDS route. The team is currently finalising the construction of a 3D printer which enables to produce RE magnets directly with the complex structure and geometry wanted, while reducing the amounts of RE material used. **Via Fused Filament Fabrication (FFF), the REProMag printer deposits highly filled plastics compounds with the desired metal powder layer after layer.** The printer is capable of dealing with both flexible and brittle filaments with high viscosity thanks to a brand new filament feeding system. The REProMag team is also driving tests with extruders for printing with granulated materials, which would mean that no filament production is required beforehand. [... next page]



¹ Arnold Magnetic Technologies, Magnet Manufacturing Process: <https://goo.gl/q7XMmG>



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Project funded by the European Union's Horizon 2020 research and innovation programme under the Grant Agreement n°636881.

(Showcasing: REProMag 3D printing solution; page 2)

Besides developing suitable equipment, **another main challenge is to supply the printer with adequate material**, also referred as feedstock material. Indeed, not only the technique but also the feedstock material determine the **stability** of the printed parts, which will need to resist **exposure to heat or corrosion** and still **prove magnetic properties strong enough** for application in fields such as mobility, energy, aerospace, industrial, mechanical engineering and medical technologies. REProMag is using recycled RE powder produced by our partner University of Birmingham².

With this powder, the REProMag team developed a special formulation of **highly filled plastic compounds** which serves as feedstock material for the printer. The feedstock material consists of a mixture of polymers which hold the magnetic particles in place during the printing procedure. Several polymers are required in the feedstock to provide **flexibility and strength** to the filament so it can be printed in a continuous and reliable manner. The next step of the SDS route – Debinding – will make sure that there is no polymer left in the magnet.



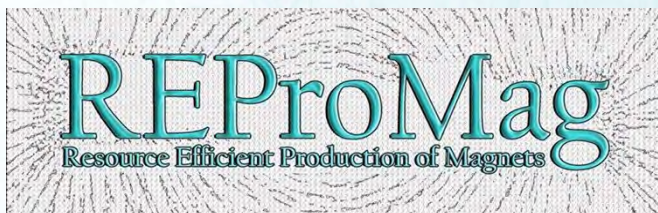
The alignment of the printed magnetic parts is under progress. Characterisation, measurements, life cycle assessment (LCA) and life cycle cost analysis (LCC) and integration into functioning demonstrators are already running in parallel. This full development approach will be the key to a broad acceptance of recycled RE-magnets via the SDS route by high-tech industries with stressful environments and thus more and more demanding standards for magnets.



² For more details about the recycling process, you can read the article „[Recycling innovation makes gadgets a little bit greener](#)” published on the BBC website on 26 August 2016 or the scientific publication: A. Walton et al. [The use of hydrogen to separate and recycle neodymium–iron–boron-type magnets from electronic waste](#). *Journal of Cleaner Production Volume 104*, 1 October 2015, Pages 236–241.



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Interview with Stefan Hampel (HAGE, Austria)



Profile: Stefan Hampel

Stefan Hampel is Member of the Executive Management at partner [HAGE Sondermaschinenbau GmbH & Co KG](#) in Obdach, Austria. He holds a Master of Science in Technical Physics and is responsible in particular for the development of innovative solutions. Stefan Hampel was born on 26 August 1968 in Austria; he is married and has two children.



How did you come to hear about the project REProMag? What convinced you to get involved?

HAGE has a close partnership with Montanuniversität Leoben; they informed us about a new EU funded project dealing with additive manufacturing (AM) of magnets. It aroused our interest as we already knew about Fused Filament Fabrication (FFF) with thermoplastics but not with metal material. FFF of metal parts is an innovative and difficult process as the metal needs to be melting while still having a certain consistence to become a filament. We thus wanted to get involved in the prospects and technical challenges of printing metals and magnets. Also, we saw promises of success in the sound mixture of organisations and backgrounds in the consortium.

Can you describe HAGE's role in the project?

HAGE is a worldwide known developer and producer of special purpose machinery especially for the automotive, railway, construction and space industry and it is our daily business to deal with new requirements. In 2012 we started with the development of 3D printing machines in the field of FFF for industrial use. Within the project we develop, design and produce a FFF machine which is able to work with the metal powder filled filaments under an inert gas atmosphere. In a second step we add a magnetisation unit with the goal to align the magnetic particles during the printing process.

Which advantages are there for your organisation in REProMag?

From the technical point of view, we learnt that we don't have to melt the metal itself: as it is embedded in powder form in a binder (polymer), it can be processed into filaments. After printing, the part is debinded and sintered and ends up as pure metal component.

A successful project allows us to broaden our range of products within the field of AM. We will be in the position to offer

the whole process chain from developing the part design together with the customer, the feedstock and the filament, delivering the equipment and doing the debinding and sintering. We can offer the part production as job order production or we can deliver the necessary equipment.

We also benefit from the very diverse consortium which allows us to get in touch with universities and basic knowledge but also with possible partners for the development of products and with potential clients in many European countries. Of course, the financial support from the European Union is very welcomed as well.

REProMag is your first Horizon 2020 project. Are you satisfied with the project so far? What would you still improve?

Yes we are satisfied. We have just started our marketing campaign for printing Titanium at the fair of Hannover. The experience gained from REProMag and the support of the partners make that possible. The organisation is excellent and the bureaucratic effort is also manageable. So we are happy with REProMag!

It does sound like a positive experience! Would you recommend taking part in research and innovation programmes supported by the European Commission?

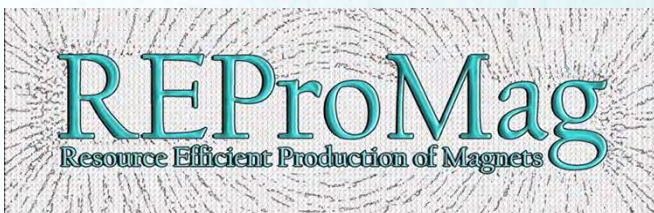
Yes we would, due to our positive experiences. Of course the programmes are the frame and the partners have to fill them with innovative spirit so it depends mostly on the good cooperation and mixture of the consortium to achieve results. The monetary support allows also small companies being a part of such large and basic projects.

So we decided to join another Horizon 2020 project – CerAMufacturing* – which deals with the additive manufacturing of metals and ceramics in a multi-material approach.

*CerAMufacturing has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 678503. www.ceramufacturing.eu



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The REProMag Academy: trainings sessions organised in the frame of our project

REProMag is a multidisciplinary project demonstrating a very diverse range of expertise in highly specialised and leading-edge domains. Therefore training activities are important tools not only to disseminate the new results achieved to students, young scientists or young professionals (technicians or engineers), but also to raise interest in the functioning of these new technologies to professionals and potential end-users.

To this aim, “REProMag Academy” was created as a set of training activities organised and led by the project partners and based on the identification and analysis of training needs and possibilities. Two types of trainings were defined: Knowledge-transfer seminars and Technology-transfer seminars.

Knowledge-transfer seminars are conceived as dissemination instruments oriented at a **wider audience, spreading knowledge and delivering visibility** to general project objectives and technological developments of REProMag. Most seminars are currently university courses.

Technology-transfer workshops are foreseen as **more interactive sessions**, where information on **specific REProMag technologies or processes** is approached in depth.

First workshop successfully completed on 30 March: Circular Economy for RE magnets

Our partner University of Birmingham (UoB) organised a workshop at the premises of its Magnetic Materials Group, Metallurgy & Materials in Birmingham, UK.

The workshop offered the opportunity to understand and discuss the advances and progress being made in the development of technologies required for a circular economy of rare earth magnets. Speakers presented work covering the full value chain of the production of recycled rare earth magnetic materials.

The workshop obtained a very positive feedback as it gathered a wide range of backgrounds – potential end users, scientists, students, measurement and assessment firms – which enabled the 35 participants to benefit from a wide range of experiences and points of view.

[Read more](#)



Save the date! Next workshop on 13 June 2017 in Leoben, Austria

Industrial applications for Additive Manufacturing (GERMAN)

[More info](#) — [programme](#) — [registration](#) until 7 June

Joint workshop with the project [addmanu](#) coordinated by Montanuniversität Leoben

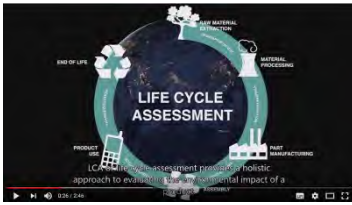


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Second project video: LCA and interview with Reinhard Bütikofer *, Member of the European Parliament ([The Greens/EFA](#)) and Co-Chair of the European Green Party (EGP)



What is **Life Cycle Assessment (LCA)** and why are we applying it to REPRoMag? Find out more with our new project video [here!](#)

For this video, we had the chance to get an interview with Member of the European Parliament Reinhard Bütikofer to discuss the importance of recycling and in particular the impact of critical material.

* Reinhard Bütikofer is a Member of the European Parliament (Greens/EFA) and the Co-Chair of the European Green Party (EGP). He sits on the Committee of Industry, Research and Energy (ITRE), is the Vice Chair of the European Parliament's Delegation for Relations with the People's Republic of China, a member of the Delegation to the United States as well as a substitute member of the Committee on Foreign Affairs (AFET). Since October 2016 he is a board member of the Green European Foundation (GEF). [Short vita](#) (English); [website](#) (German); [Reinhard Bütikofer's page on the European Parliament website](#)



REPRoMag at STEM for BRITAIN (13 March 2017)

Nick Hillier, Research Scientist at our partner NPL, (National Physical Laboratory, Teddington, UK) presented a **poster about REPRoMag and characterisation** at the British Parliament in the frame of the STEM for Britain competition. [More](#)

26. Leobener Kunststoff-Kolloquium: Innovative Spritzgießtechnologie – Trends und aktuelle Entwicklungen in Leoben, Austria (20-21 April 2017)

The 26th Leoben colloquium had as major topic "Innovative Injection Moulding Technology – Trends and Actual Developments". It was co-organised by our partner MUL (Montanuniversität Leoben, Austria) and PCCL (Polymer Competence Center Leoben). MUL presented the **poster "Metal Injection Moulding for the Production of Recycled Rare Earth Magnets"** with outcomes from REPRoMag. [More information](#) (German).

ICIT & APT in Ljubljana, Slovenia (24-26 April 2017)

The 10th International Conference on Industrial Tools and Advanced Processing Technologies focused on most recent advances in the production technologies that are currently being incorporated in the industry - where 4th industrially revolution is transforming current production plants to the next level: INDUSTRY 4.0 - the Factories of the Future.

Besides of presenting the latest results from REPRoMag, our partner MUL also held two talks on the SDS process and Molecular Dynamics Simulations. [Abstracts](#). [More](#)

Hannover Messe in Germany (24-28 April 2017)

Partner HAGE (Obdach, Austria) presented its **HAGE3D Titanium composite materials** for accelerated, optimised shaping with the **SDS process**, designed with partner OBE (Ispringen, Germany). The result: reduction of raw material consumption and saving of resources and energy during the production process. [More](#)

Upcoming events

ANTEC® – The plastics technology conference, 8-10 May 2017, USA

Will boast technical and business presentations on new and updated technologies, panels and tutorials, networking events and student functions - face-to-face interaction with expert representatives from the largest industry segments. **Meet our partner MUL there!** [More](#)

ERES 2017 – The 2nd Conference on European Rare Earth Resources, 28-31 May 2017, Greece

Will include both geological and metallurgical topics for production of REE from primary and secondary REE resources. Oral presentations and poster presentations. [More](#)

The 19th Plansee Seminar, 29 May-2 June 2017, Austria

Will present new insights in the field of Refractory Metals and Hard Materials. Applications, materials, processes and testing methods will be addressed in key-note lectures and contributed papers. The latter will be presented in oral and poster sessions. **Meet our partner MUL there!** [More](#)

World Circular Economy Forum, 5-7 June 2017, Finland

Will present the world's best circular economy solutions and gathers together the most recognised experts and decision makers in the field. [More](#)

Rare Earths, Lithium & Graphite for Automotive Magnets & Batteries Conference, 19-20 June 2017, UK

Will examine developments in the materials being used in magnets and battery technology, which are all key components of electric/HE vehicles. [More](#)

REPRoMag Final Event

Our final event will showcase our project's achievements, machines and demonstrator parts and is foreseen to take place in October or November—we will keep you informed and would be pleased to see you there!



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